United States Department of Agriculture

Forest Service

North Central Forest Experiment Station

Research Paper NC-215

Projecting Treatment Opportunities for Current Minnesota Forest Conditions

W. Brad Smith and Pamela J. Jakes

North Central Forest Experiment Station
Forest Service—U.S. Department of Agriculture
1992 Folwell Avenue
St. Paul, Minnesota 55108

Manuscript approved for publication November 24, 1980
1981

PROJECTING TREATMENT OPPORTUNITIES FOR CURRENT MINNESOTA FOREST CONDITIONS

W. Brad Smith,
Associate Mensurationist,
and **Pamela J. Jakes,**
Associate Resource Analyst

Resource evaluation is a continuing task required by the Forest and Rangeland Renewable Resources Planning Act of 1974 (P.L. 93-378). One objective of the Act is the evaluation of timber management opportunities. In partial fulfillment of this objective, treatment opportunities were analyzed for projected Minnesota forest conditions in the decade 1977-1986. Three treatments were considered: (1) final harvest, (2) timber stand improvement (t.s.i.—consisting of commercial and noncommercial thinning or cull tree removal), and (3) stand conversion or restocking. Stand conditions were compared to treatment criteria, and the area qualifying for each treatment during the decade was determined. Volumes occurring on potential harvest and t.s.i. areas were calculated, and represent the volumes that could be expected if the treatments were carried out. **There is no correct or single estimate of the area qualifying for treatment, rather acreage varies according to the treatment criteria specified. This paper presents just one of many possible management scenarios for Minnesota's forests but conforms to generally accepted silvicultural practices.**

ASSUMPTIONS

Three major assumptions were made: (1) the area of commercial forest land would remain stable for the decade 1977-1986, (2) all commercial forest land is available for treatment, and (3) markets exist for all species and products. **The analysis did not consider possible economic, social, or political constraints on timber management.**

It was also assumed desirable to evenly distribute acreage by age class within each forest type by the end of one rotation, and that an equal area would be cut every decade of the rotation. Treatment opportunities were projected for a 10-year period, after which time they should be reassessed in light of changes in forest type area, forest management practices, and management objectives.

METHODS

Three broad treatment categories were identified for Minnesota: (1) final harvest, (2) timber stand improvement (t.s.i.—thinning or cull tree removal), and (3) stand conversion or restocking. Harvest cuts are final cuts followed by artificial or natural regeneration. Thus it was not necessary to include harvest acreage in the category stand conversion or restocking.

The logic used to assign treatments to each forest inventory plot is diagrammed in figure 1. The process is described in detail below:

(1) **Identify areas for harvest**

Treatment criteria (table 1) were used in an area control algorithm to calculate harvest acreage by Forest Survey Unit for each forest type for the decade 1977-1986 such that acreage would be evenly distributed among age classes by the end of one rotation, and an equal area would be cut during every decade of the rotation. Rotation ages for each forest type generally vary depending on management objectives. Again we emphasize that the set of harvest criteria used in this report is just one of many options possible.[1]

---

[1]*For a more detailed discussion of harvest options for northern Minnesota, see: Jakes, Pamela J., and W. Brad Smith. 1980. Predicted yields from selected cutting prescriptions in northern Minnesota. U.S. Department of Agriculture Forest Service, Research Paper NC-188, 29 p. U.S. Department of Agriculture Forest Service, North Central Forest Experiment Station, St. Paul, Minnesota.*

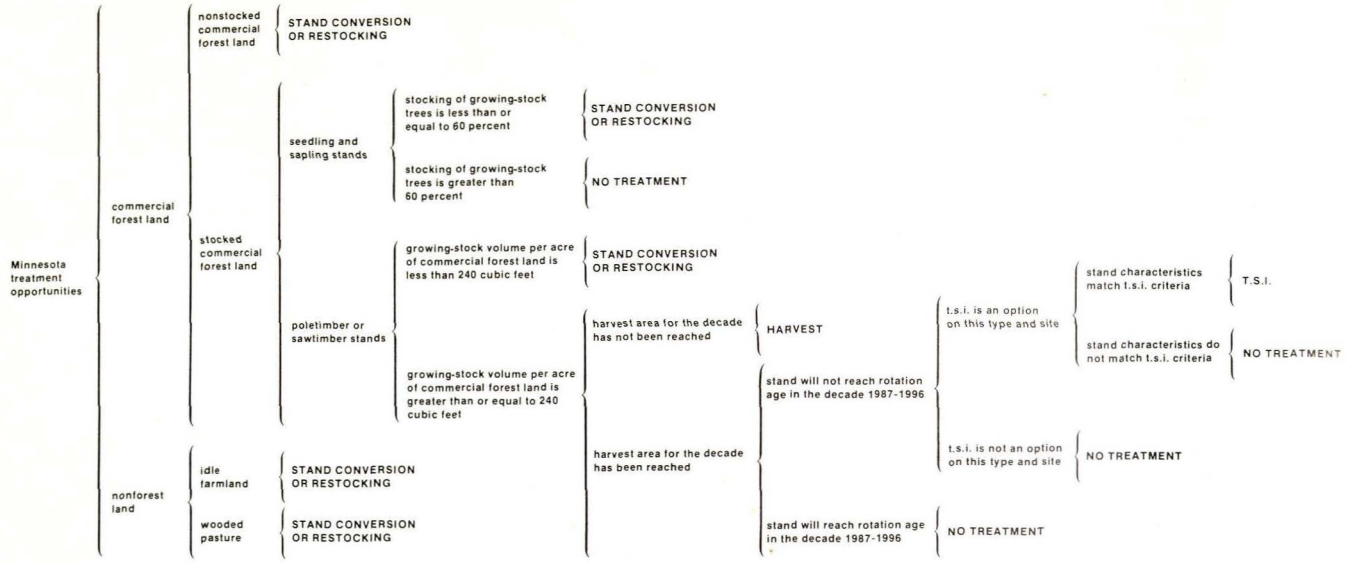
Minnesota treatment opportunities
commercial forest land
nonstocked commercial forest land
STAND CONVERSION OR RESTOCKING
stocked commercial forest land
seedling and sapling stands
stocking of growing-stock trees is less than or equal to 60 percent
STAND CONVERSION OR RESTOCKING
stocking of growing-stock trees is greater than 60 percent
NO TREATMENT
poletimber or sawtimber stands
growing-stock volume per acre of commercial forest land is less than 240 cubic feet
STAND CONVERSION OR RESTOCKING
growing-stock volume per acre of commercial forest land is greater than or equal to 240 cubic feet
harvest area for the decade has not been reached
HARVEST
t.s.i. is an option on this type and site
stand characteristics match t.s.i. criteria
T.S.I.
stand characteristics do not match t.s.i. criteria
NO TREATMENT
stand will not reach rotation age in the decade 1987-1996
t.s.i. is not an option on this type and site
NO TREATMENT
harvest area for the decade has been reached
nonforest land
idle farmland
STAND CONVERSION OR RESTOCKING
wooded pasture
STAND CONVERSION OR RESTOCKING
stand will reach rotation age in the decade 1987-1996
NO TREATMENT

Figure 1.— *Logic used in assigning forest inventory plots to treatment categories, Minnesota, 1977-1986. The oldest stands in each forest type-site index range are processed first.*

Because treatments would occur throughout the 10-year period, an estimate of the average annual volumes removed during the treatment must reflect the growth that would occur on plots between 1977 (when the data were collected) and the time of treatment. For this reason, it was necessary to project each plot's growth for 5 years as an estimate of average growth for the decade. To accomplish this, plot growth from the 1977 Minnesota Forest Inventory was projected by a modified version of the Tree Growth Projection System of the Forest Resources Evaluation Program (FREP).[2] Seedling and sapling stands, nonstocked commercial forest land, and commercial forest plots with less than 240 cubic feet of growing-stock per acre were not projected by the System. The System "grew" each plot for 5 years, calculating areas and volumes represented by the plots. Because a shift in commercial forest area between stand-age classes occurred on some plots during the projection, the resulting area treated in a stand-age class cannot be directly compared to the area in the stand-age class as reported in the 1977 Minnesota Forest Inventory.

[2]*U.S. Department of Agriculture, Forest Service. 1979. A generalized forest growth projection system applied to the Lake States region. U.S. Department of Agriculture Forest Service, General Technical Report NC-49, 96 p. U.S. Department of Agriculture Forest Service, North Central Forest Experiment Station, St. Paul, Minnesota.*

Finally, for each forest type and site index range, plots were selected for harvest until the area "cut" equalled the recommended harvest area calculated by the area control algorithm for the decade. The System assigned the highest cutting priority to overmature stands.

(2) **Identifying areas for timber stand improvement**

Data from projected plots not selected for harvest were compared to t.s.i. criteria shown in table 1. Area suitable for t.s.i. was calculated and the volumes removed during t.s.i. were estimated. Any stand within 10 years of rotation age was not considered for t.s.i.

Criteria for t.s.i. came from two sources. Criteria for most forest types were reached by compromise among representatives of Minnesota's forest industries and the Department of Natural Resources. For the balsam fir, white spruce, maple-basswood, and oak-hickory forest types, criteria were obtained from management guides identified in the Appendix.

On plots selected for t.s.i., the Tree Growth Projection System assigned the highest thinning priority to cull trees, then growing-stock trees of undesirable species, and finally growing-stock crop trees. Large-diameter growing stock crop trees are favored for retention during thinning. Trees were "thinned" from the plot until the recommended basal area or other stand criteria were met.

Table 1.--Harvest and timber stand improvement criteria[1/] used in assessing treatment opportunities, Minnesota, 1977-1986

Forest type	Harvest criteria		Timber stand improvement criteria	
	Site index range	Rotation age	Basal area for thinning	Post thinning basal area
	Feet	Years	Square feet	
Jack pine	0-60	50	120	2/3 of original basal area
	61+	60		
Red pine	0-55	100	120	90
	56+	120		
White pine	0-55	100	120	90
	56+	120		
Balsam fir	all	50	FREP guides[2/]	
White spruce	all	80	FREP guides[2/]	
Black spruce	0-40	120	no thinning	
	41+	90		
Northern white-cedar	all	100	no thinning	
Tamarack	0-40	120	no thinning	
	41+	90		
Oak-hickory	0-55	100	FREP guides[2/]	
	56+	80		
Elm-ash-cottonwood	0-55	70	100	65
	56+	90		
Maple-basswood	all	90	FREP guides[2/]	
Aspen	0-65	40	no thinning	
	66+	60		
Paper birch	0-65	40	no thinning	
	66+	60		
Balsam poplar	0-65	40	no thinning	
	66+	60		

[1/] Management criteria agreed upon by representatives from Minnesota's forest industries and Department of Natural Resources except where otherwise noted.

[2/] Guides listed in the appendix.

(3) Identifying areas for stand conversion or restocking

Areas for stand conversion or restocking were identified using the Renewable Resources Evaluation Project's data retrieval system. All sawtimber or poletimber stands with less than 240 cubic feet of growing stock per acre were recommended for conversion or restocking. Seedling and sapling stands less than 61 percent stocked with growing-stock trees also received this treatment. Other areas selected for stand conversion or restocking include nonstocked commercial forest land, idle farmland, and wooded pasture. Volume estimates on areas in the conversion and restocking treatment category represent static volumes from the 1977 forest inventory, and were not projected for the decade 1977-1986. In practice, well-stocked commercial forest land may be converted to other forest types following harvest, but this is not reflected in the treatment category.

(4) **Identifying areas requiring no treatment**

All commercial forest land not qualifying for one of the treatments discussed above received no treatment.

RESULTS
Harvest Treatment Opportunities

According to the harvest criteria outlined in table 1, 2.2 million acres of commercial forest could be harvested during the decade 1977-1986 (table 2). Nearly half of the harvest acreage is in aspen, the remaining acreage is scattered among a number of forest types.

Although all stands over 140 years old were scheduled for harvest, the majority of the harvest acreage was found in stands less than 71 years old (table 3, Appendix). Most stands more than 10 years past rotation age during the decade were harvested. However, in some forest types, for example northern white-cedar and paper birch, type acreage was so heavily concentrated in overmature stands that some stands more than 10 years past rotation age were left for harvest until the decade 1987-1996. In forest types where stands far younger than harvest age predominate, some areas were harvested before they reached rotation age.

Stands were harvested from all stand volume classes, the largest area occurring in the highest class, with at least 1,600 cubic feet of growing stock per acre (table 4, Appendix). In the red pine forest type, 89 percent of the commercial forest area selected for harvest was in the highest stand volume class. Balsam fir, on the other hand, had over half of its harvest area in stand volume classes with less than 800 cubic feet of growing stock per acre.

Average annual harvest volume of growing stock would be 281.9 million cubic feet (table 5, Appendix). Growing-stock harvest volume is concentrated in hardwood species. The average annual harvest volume from aspen species totaled 100.2 million cubic feet, more than the entire softwood harvest. While hardwood harvest volume was fairly evenly divided between poletimber and sawtimber stands (95.6 million cubic feet and 97.0 million cubic feet, respectively), softwood harvest was concentrated in sawtimber stands.

In addition to the 281.9 million cubic feet of growing stock, 29.6 million cubic feet of cull trees could be

Table 2.--Treatment opportunities on commercial forest land and nonforest land with trees by land class and forest type, Minnesota 1977-1986

(In thousand acres)

Land class and forest type	All treatments	Treatments			
		Harvest	T.S.I.	Stand conversion or restocking	No treatment
COMMERCIAL FOREST:					
Jack pine	507.1	94.0	8.2	19.2	385.7
Red pine	246.9	23.2	13.7	7.8	202.2
White pine	65.6	5.9	3.7	3.1	52.9
Balsam fir	867.5	166.6	19.0	58.1	623.8
White spruce	79.2	10.0	6.1	12.4	50.7
Black spruce	1,072.8	85.0	--	146.4	841.4
Northern white-cedar	502.2	46.3	--	52.2	403.7
Tamarack	482.2	44.0	--	114.8	323.4
Oak-hickory	902.9	98.5	115.5	59.1	629.8
Elm-ash-cottonwood	755.7	93.8	--	99.1	562.8
Maple-basswood	1,288.2	139.5	--	91.8	1,056.9
Aspen	5,361.6	1,074.3	--	504.7	3,782.6
Paper birch	1,006.7	224.9	--	53.3	728.5
Balsam poplar	556.5	116.9	--	94.5	345.1
Subtotal	13,695.1	2,222.9	166.2	1,316.5	9,989.5
NONFOREST:					
Idle farmland	55.0	--	--	55.0	--
Wooded pasture	135.0	--	--	135.0	--
Subtotal	190.0	--	--	190.0	--
All classes	13,885.1	2,222.9	166.2	1,506.5	9.989.5

removed annually from the harvest area. Short-log trees account for the majority of the cull tree harvest volume. For most species, cull tree volume did not contribute significantly to the total harvest volume for the species. An exception was hard maple where 43 percent of the harvest volume was in cull trees, as compared to 9 percent for all species.

The aspen forest type, with 48 percent of the harvest area, provided 59 percent of the average annual harvest volume (table 6, Appendix). More than 70 percent of the hardwood harvest volume was found in the type. Significant percentages of the harvest volumes of several softwood species were also found in aspen stands. Fifty-nine percent of the white spruce, 54 percent of the white pine, and 47 percent of the balsam fir harvest volumes were in the aspen forest type.

Timber Stand Improvement Treatment Opportunities

Following the criteria outlined in table 1, t.s.i. would occur on 166,200 acres of commercial forest land during the decade (table 2). Most (69 percent) of the t.s.i. work would occur in the oak-hickory forest type, where many 31- to 50-year-old stands were overstocked and would benefit from thinning or cull tree removal (table 7, Appendix).

Half of the timber stand improvement acreage was in stand-volume classes with at least 1,200 cubic feet of growing stock per acre (table 8, Appendix). Only in the oak-hickory forest type was t.s.i. acreage found in the lowest stand volume class (240 to 399 cubic feet of growing-stock per acre).

The average annual volume removed during t.s.i. operations over the decade would be 5.1 million cubic feet—3.8 million cubic feet in growing stock (table 9, Appendix). Aspen and balsam fir accounted for the majority of the t.s.i. growing-stock volume. For most species, more volume was removed in poletimber size trees than sawtimber size trees during t.s.i. operations. Exceptions to this included white pine, white spruce, and tamarack.

Cull trees accounted for more than one-fourth of the total average annual volume removed during t.s.i. operations. In the oak species, cull removals from t.s.i. were greater than growing-stock removals. Rough and rotten trees account for a larger portion of the cull volume than short-log trees.

Timber stand improvement growing-stock volume, like area, is concentrated in the oak-hickory forest type (table 10, Appendix). Balsam fir, white spruce, and white pine forest types accounted for most of the remaining volume.

Stand Conversion or Restocking Opportunities

Nearly 10 percent of Minnesota's 1977 commercial forest area would undergo stand conversion or restocking during the decade under the treatment criteria used in this study (table 2). An additional 190,000 acres of nonforest land would be converted to commercial forest land.

The largest portion of the commercial forest land in this treatment category was in the aspen forest type (table 11, Appendix). Over half of the commercial forest acreage selected for stand conversion or restocking was in stands less than 21 years old. The few stands over 80 years selected for stand conversion or restocking were poletimber or sawtimber stands with less than 240 cubic feet of growing-stock volume per acre.

Volume on commercial forest land selected for stand conversion or restocking totaled 237.3 million cubic feet—146.9 million cubic feet in growing stock, 90.4 million cubic feet in cull trees (table 12, Appendix). Cull volume exceeded growing-stock volume on commercial forest land in this treatment category for several species groups. The largest portions of the growing-stock and cull volumes were found in the aspen species.

Although the aspen forest type accounted for 38 percent of the commercial forest area in the treatment category, the type had 44 percent of the growing-stock volume (table 13, Appendix). The 44.9 million cubic feet of softwood volume were concentrated in the tamarack, aspen, and black spruce forest types. Most of the hardwood growing-stock volume was in the aspen forest type.

No Treatment

Under the treatment criteria specified, 10.0 million acres of commercial forest land (73 percent) would receive no treatment during the decade (table 2). In most forest types, at least 70 percent of the type acreage would receive no treatment. Exceptions included balsam poplar (62 percent), white spruce (64 percent), and tamarack (67 percent) forest types. The majority of the commercial forest area receiving no treatment was in stands less than 51 years of age (table 14, Appendix).

DISCUSSION

According to the criteria outlined earlier, 3.7 million acres of commercial forest land and 190,000 acres of nonforest land would require some forest treatment during the decade 1977-1986.

There are many reasons why these treatments may not be carried out. Wood production may not be a priority for some land owners. These owners may consider timber management incompatible with their objectives. Traditional markets may not exist for some of the products removed during treatment; however, with increasing interest in wood biomass for energy and other new products, new markets may open up. Physical features (i.e., physiographic class, slope, stand area, distance to transportation systems) may make some sites uneconomical. Administrative regulations may limit treatment options in other areas. For these reasons, the acreage recommended for various treatments in this report is a biological maximum, given the treatment criteria and current Minnesota forest conditions. Forest managers and planners can use their knowledge to temper these findings to fit local resource conditions.

The most common treatment during the decade would be harvest operations on 2.2 million acres or 16 percent of commercial forest land during the decade. In several forest types, at least 20 percent of the commercial forest area of the type would be harvested under the criteria specified—these include aspen (20 percent), balsam poplar (21 percent), and paper birch (22 percent). Data were collected during the fourth Minnesota forest inventory on plots outside the National Forests describing treatments occurring since 1962. The data indicate that only 0.7 percent of the non-National Forest commercial forest land was harvested annually. The findings of this study recommend harvesting 1.6 percent of all commercial forest land annually, over twice that found on the non-National Forest land.

As indicated earlier, some stands more than 10 years past rotation age were not harvested. This action was necessary to achieve the area control objectives—an even area distribution among age classes within a forest type by the end of one rotation, and harvest of an equal area during every decade of the rotation. In other forest types, stands were harvested as much as 50 years before rotation age so that the area control objectives could be achieved. Harvesting these "undermature" stands was not perceived as a major problem because the rotation ages in table 1 are compromise rotation ages; in actual practice, harvest often takes place at ages far below those chosen in this study. The acres cut by the System in the younger age classes fall within the lower limits. Also, in the forest types where stands are harvested below the rotation ages specified in table 1, a market exists for the products.

Timber stand improvement work in the oak-hickory forest type would occur on 65 percent of the type acreage in the 31- to 40-year age class and 52 percent of the type acreage in the 41- to 50-year age class. This relatively heavy t.s.i. work in the oak-hickory forest type reflects the belief of forest managers that the greatest individual tree growth in oak-hickory stands is obtained at the lower limits of stocking for full site utilization.[3]

Most (60 percent) of the 1.5 million acres targeted for stand conversion or restocking is commercial forest land in seedling and sapling stands less than 61 percent stocked with growing-stock:

	Area qualifying for stand conversion or restocking
Commercial forest land:	*Acres*
Seedling and sapling stands	904,800
Poletimber and sawtimber stands	242,300
Nonstocked commercial forest land	169,400
Subtotal	1,316,500
Nonforest land:	
Wooded pasture	135,000
Idle farmland	55,000
Subtotal	190,000
Total	1,506,500

In all forest types, with the exception of northern white-cedar, the majority of the area selected for stand conversion or restocking is in seedling and sapling stands (table 15, Appendix). In the northern white-cedar forest type, 68 percent of the area in the treatment category is in poletimber or sawtimber stands with less than 240 cubic feet per acre.

The assumptions and treatment criteria in this study were necessarily broad. However, by using other available inventory data, assumptions and criteria can be tightened to reflect more closely those of a particular user or region. As an example, more detailed inventory data drawn from the Project's data retrieval system indicates that a large portion of the area selected for stand conversion or restocking may be inoperable.

---

[3]*Sander, Ivan L. 1977. Manager's handbook for oaks in the North Central States. U.S. Department of Agriculture Forest Service, General Technical Report NC-37, 35 p. U.S. Department of Agriculture Forest Service, North Central Forest Experiment Station, St. Paul, Minnesota.*

The average site index of stands selected for stand conversion or restocking is 48, approximately 16 percent lower than the average site index of stands in all other treatment categories:

Site index class	Commercial forest land selected for stand conversion or restocking	Commercial forest land in all other treatment categories
	Thousand acres	
0-20	38.2	85.0
21-30	140.0	664.8
31-40	230.9	1,160.9
41-50	331.5	2,143.5
51-60	279.0	3,171.4
61-70	207.5	2,884.8
71-80	76.1	1,643.0
81-90	10.5	556.6
91+	2.8	68.6
All classes	1,316.5	12,378.6

A larger portion of the stands in the low site index classes were recommended for stand conversion or restocking than the high site index classes. In site index class 0-20, 31 percent of the acreage qualified for stand conversion or restocking; in class 21-30, 17 percent qualified. At the other end of the site index scale, 2 percent of the commercial forest area in site index class 81-90 would undergo stand conversion or restocking, 4 percent in site index class 91+. Low site index ratings may mean that it would not be feasible to expend large amounts of time or money managing the current forest type, but the site could be more fully utilized by another type.

Stand conversion or restocking opportunities average 26 acres in size, with 63 percent of the area in homogeneous forest blocks less than 10 acres of the same forest type, size of timber, and density. The average stand area of commercial forest land in all other treatment categories is 50 acres. This may indicate that some stands selected for stand conversion or restocking are too small in area to be economically treated individually.

Stand area class	Commercial forest land selected for stand conversion or restocking	Commercial forest land in all other treatment categories
	Thousand acres	
1-4	550.5	2,968.6
4-9	279.0	2,584.0
10-19	200.8	2,303.9
20-39	118.3	1,796.3
40-79	70.1	948.4
80-159	66.4	1,094.1
160-319	15.2	265.3
320-639	9.6	142.8
640+	6.6	275.2
All classes	1,316.5	12,378.6

Ideally, the removal of timber volume from stands selected for stand conversion or restocking could help defray some of the management costs. However, the total volume occurring on these lands averages 180 cubic feet per acre, with growing-stock volume per acre only 112 cubic feet.

Nonforest areas targeted for restocking include 55,000 acres of idle farmland and 135,000 acres of wooded pasture. Between 1962 and 1977, only 19,600 acres of nonforest land were converted to commercial forest land outside the National Forests. Wooded pasture is area sufficiently stocked with timber to be classified as commercial forest land, but the primary land use is grazing rather than wood production. In many instances, restricting cattle or other grazers from the wooded pasture would allow regeneration to prosper, resulting in adequately stocked commercial forest land.

Wooded pasture is concentrated in the Central Hardwood Unit and is occupied primarily by hardwood forest types:

Forest type	Area of wooded pasture
	Acres
White pine	3,500
Oak-hickory	30,700
Elm-ash-cottonwood	21,800
Maple-basswood	26,900
Aspen	34,300
Paper birch	7,900
Balsam poplar	9,900
Total	135,000

Wooded pasture sites range from site index 35 to site index 75, with the following distribution among site index classes:

Site index class	Area of wooded pasture
	Acres
31-40	23,800
41-50	44,300
51-60	32,700
61-70	30,700
71-80	3,500
Total	135,000

The idle farmland selected for stand conversion or restocking is farmland that has not been tended within the last 2 years but is less than 16.7 percent stocked with all live trees. Idle farmland is most common in the Aspen-Birch and Northern Pine Forest Survey Units.

In many cases, this type of more detailed inventory data is available at cost to the public, however personnel time constraints may make the request turn-around time lengthy.

APPENDIX

MANAGEMENT GUIDES USED IN FREP AND APPLIED TO T.S.I. AREA ESTIMATES[4]

Balsam fir	U.S. Forest Service. 1967. Silvicultural practices handbook. Chapter 100—spruce-fir type.
White spruce	U.S. Forest Service. 1967. Silvicultural practices handbook. Chapter 100—spruce-fir type.
Maple-basswood	Tubbs, Carl H. 1977. Manager's handbook for northern hardwoods in the North Central States. U.S. Department of Agriculture Forest Service, General Technical Report NC-39, 29 p. U.S. Department of Agriculture Forest Service, North Central Forest Experiment Station, St. Paul, Minnesota. Godman, Richard M. Research forester, North Central Forest Experiment Station, Rhinelander, Wisconsin. Personal communication with Gary Brand, Research forester, North Central Forest Experiment Station, St. Paul, Minnesota.
Oak-hickory	Sander, Ivan L. 1977. Manager's handbook for oaks in the North Central States. U.S. Department of Agriculture Forest Service, General Technical Report NC-37, 35 p. U.S. Department of Agriculture Forest Service, North Central Forest Experiment Station, St. Paul, Minnesota.

[4]*Brand, Gary. 1981. Simulating timber management in Lake States' forests. U.S. Department of Agriculture Forest Service, General Technical Report NC-69, 25 p. U.S. Department of Agriculture Forest Service, North Central Forest Experiment Station, St. Paul, Minnesota.*

DEFINITION OF TERMS

Land-Use Classes

Forest land.—Land at least 16.7 percent stocked by forest trees of any size, or formerly having such tree cover, and not currently developed for nonforest use. Includes afforested areas. The minimum forest area classified was 1 acre. Roadside, streamside, and shelterbelt strips of timber must have a crown width of at least 120 feet to qualify as forest land. Unimproved roads and trails, streams, and clearings in forest areas were classed as forest if less than 120 feet in width.

Commercial forest land.—Forest land that is producing or is capable of producing crops of industrial wood and that is not withdrawn from timber utilization by statute or administrative regulation. This includes areas suitable for management to grow crops of industrial wood generally of a site quality capable of producing in excess of 20 cubic feet per acre of annual growth. This includes both inaccessible and inoperable areas.

Noncommercial forest land.—(a) *Unproductive*—forest land incapable of yielding crops of industrial wood because of adverse site conditions, (b) *Productive-reserved*—forest land withdrawn from commercial timber use through statute or administrative regulation, or exclusively used for Christmas tree production.

Nonforest land.—Land that has never supported forests, and land formerly forested where forest use is precluded by development for nonforest uses, such as cropland, improved pasture, residential areas, and city parks. Also includes improved roads and adjoining rights-of-way, powerline clearings, and certain areas of water classified by the Bureau of Census as land. Unimproved roads, streams, canals, and nonforest strips in forest areas must be more than 120 feet wide, and clearings in forested areas must be more than 1 acre in size, to qualify as nonforest land.

Tree Classes

All live trees.—Growing-stock, rough, and rotten trees 1 inch d.b.h. and larger.

Growing-stock trees.—All live trees of commercial species except rough and rotten trees.

Sawtimber trees.—Growing-stock trees of commercial species containing at least a 12-foot saw log or two noncontiguous saw logs, each 8 feet or longer. At least 33 percent of the gross volume of the tree must be sound wood. Softwoods must be at least 9 inches d.b.h. and hardwoods at least 11 inches.

Poletimber trees.—Growing-stock trees of commercial species at least 5 inches d.b.h. but smaller than sawtimber size, and of good form and vigor.

Saplings.—Live trees of commercial species 1 to 5 inches d.b.h. and of good form and vigor.

Seedlings.—Live trees of commercial species less than 1 inch d.b.h. that are expected to survive according to regional standards. (Examples of seedlings not expected to survive are those that are diseased or heavily damaged by logging, browsing, or fire.) Only softwood seedlings over 6 inches and hardwood seedlings over 1 foot in height are counted.

Rotten trees.—Live trees (any size) of commercial species that do not contain a merchantable 12-foot saw log or two noncontiguous 8-foot or longer saw logs, now or prospectively, because of rot (that is, when more than 50 percent of the cull volume of the tree is rotten).

Rough trees.—Live trees that do not contain at least one merchantable 12-foot saw log or two noncontiguous 8-foot or longer saw logs, now or prospectively, because of roughness and poor form, as well as all live noncommercial species.

Short-log (rough trees).—Sawtimber-size trees of commercial species that contain at least one merchantable 8- to 11-foot saw log but not a 12-foot saw log.

Other Classifications

Site index.—An expression of forest site quality based on the height of a free-growing dominant or codominant tree of a representative species in the forest type at age 50.

Stand age.—Age of the main stand. Main stand refers to trees of the dominant forest type and stand-size class.

Basal area.—The area in square feet of the cross section at breast height of a single tree. When the basal areas of all the trees in a stand are summed, the result is usually expressed as square feet of basal area per acre.

Nonstocked areas.—Commercial forest land on which stocking of growing-stock trees is less than 16.7 percent.

Forest Types

A classification of forest land based upon the species forming a plurality of live-tree stocking. Major forest types in Minnesota are:

Jack pine.—Forests in which jack pine comprises a plurality of the stocking. (Common associates include eastern white pine, red pine, aspen, birch, and maple.)

Red pine.—Forests in which red pine comprises a plurality of the stocking. (Common associates include eastern white pine, jack pine, aspen, birch, and maple.)

White pine.—Forests in which eastern white pine comprises a plurality of the stocking. (Common associates include red pine, jack pine, aspen, birch, and maple.)

Balsam fir.—Forests in which balsam fir and white spruce comprise a plurality of stocking with balsam fir the most common. (Common associates include white spruce, aspen, maple, birch, northern white-cedar, and tamarack.)

White spruce.—Forests in which white spruce and balsam fir comprise a plurality of the stocking with white spruce the most common. (Common associates include balsam fir, aspen, maple, birch, northern white-cedar, and tamarack.)

Black spruce.—Forests in which swamp conifers comprise a plurality of the stocking with black spruce the most common. (Common associates include tamarack and northern white-cedar.)

Northern white-cedar.—Forests in which swamp conifers comprise a plurality of the stocking with northern white-cedar the most common. (Common associates include tamarack and black spruce.)

Tamarack.—Forests in which swamp conifers comprise a plurality of the stocking with tamarack the most common. (Common asssociates include black spruce and northern white-cedar.)

Oak.—Forests in which northern red oak, white oak, or bur oak, singly or in a combination, comprise a plurality of the stocking. (Common associates include elm, maple, and aspen.)

Elm-ash-cottonwood.—Forests in which lowland elm, ash, cottonwood, and red maple, singly or in combination, comprise a plurality of the stocking. (Common associates include basswood and balsam poplar.)

Maple-basswood.—Forests in which sugar maple, basswood, yellow birch, upland American elm, and red maple, singly or in combination, comprise a plurality of the stocking. (Common associates include white pine and elm.)

Aspen.—Forests in which quaking aspen or bigtooth aspen, singly or in combination, comprise a plurality of the stocking. (Common associates include balsam poplar, balsam fir, and paper birch.)

Paper birch.—Forests in which paper birch comprises a plurality of the stocking. (Common associates include maple, aspen, and balsam fir.)

Balsam poplar.—Forests in which balsam poplar comprises a plurality of the stocking. (Common associates include aspen, elm, and ash.)

Timber Volume

Volume of growing-stock.—The volume of sound wood in the bole of growing-stock trees 5 inches d.b.h. and over, from a 1-foot stump to a minimum of 4-inch top diameter outside bark, or to the point where the central stem breaks into limbs. Growing-stock volumes are shown in cubic feet. Conversion to cords may be accomplished by a factor of 79 cubic feet per solid wood cord.

Volume of sawtimber.—Net volume of the saw log portion of live sawtimber trees in board feet (International ¼-inch rule) from stump to a minimum 7 inches top diameter outside bark for softwoods and 9 inches for hardwoods.

Upper stem portion.—That part of the bole of sawtimber trees above the merchantable sawtimber top to a minimum top diameter of 4 inches outside bark or to the point where the central stem breaks into limbs.

Growth and Mortality

Net volume growth of growing stock.—The annual change in volume of sound wood in live growing-stock and sawtimber trees and total volume of trees entering these classes through ingrowth, less volume losses resulting from natural causes.

Net annual growth of sawtimber.—The annual change in volume of live sawtimber trees and the total volume of trees reaching sawtimber size, less volume losses resulting from natural causes.

Mortality of growing stock.—The volume of sound wood in growing-stock trees dying annally from natural causes. Natural causes include fire, insects, disease, animal damage, weather, and suppression.

Mortality of sawtimber.—The net board-foot volume of sawtimber trees dying annually from natural causes.

Table 3.--Commercial forest area qualifying for harvest during the decade 1977-1986 by forest type and stand-age class, Minnesota

(In thousand acres)

Forest type	All classes	Stand-age class (years)										
		Less than 31	31-40	41-50	51-60	61-70	71-80	81-90	91-100	101-120	121-140	141+
Jack pine	94.0	--	--	1.0	27.9	31.7	7.8	12.2	10.7	2.7	--	--
Red pine	23.2	--	--	--	2.1	2.1	0	6.5	9.8	2.7	--	--
White pine	5.9	--	--	--	--	0.4	0.2	0	3.1	2.2	--	--
Balsam fir	166.6	--	--	0.2	28.7	80.4	35.8	9.7	9.1	2.7	--	--
White spruce	10.0	--	--	--	--	2.5	1.2	2.5	2.7	1.1	--	--
Black spruce	85.0	--	--	--	0.3	3.1	8.4	18.3	28.8	13.6	12.5	--
Northern white-cedar	46.3	--	--	--	--	--	--	--	--	--	42.2	4.1
Tamarack	44.0	--	--	--	--	1.9	3.1	--	0.7	14.2	22.9	1.2
Oak-hickory	98.5	--	--	0.3	0.4	4.4	5.6	16.2	20.3	43.7	7.6	--
Elm-ash-cottonwood	93.8	--	--	--	--	--	3.6	3.3	35.8	31.7	19.4	--
Maple-basswood	139.5	--	--	--	--	--	--	0.1	49.8	56.6	33.0	--
Aspen	1,074.3	--	--	37.7	492.3	345.2	125.0	53.2	15.0	4.5	1.4	--
Paper birch	224.9	--	--	--	4.4	94.3	72.1	40.6	8.2	5.3	--	--
Balsam poplar	116.9	--	0.5	6.6	38.5	37.5	25.3	7.1	1.4	--	--	--
All types	2,222.9	--	0.5	45.8	594.6	603.5	288.1	169.7	195.4	181.0	139.0	5.3

Table 4.--Commercial forest area qualifying for harvest during the decade 1977-1986 by forest type and stand-volume class, Minnesota

(In thousand acres)

Forest type	Total	Stand-volume class (cubic feet of growing stock per acre) 240-399	400-799	800-1199	1200-1599	1600+
Jack pine	94.0	1.1	14.5	17.1	20.7	40.6
Red pine	23.2	--	--	1.1	1.4	20.7
White pine	5.9	--	0.3	1.1	0.6	3.9
Balsam fir	166.6	45.0	42.3	37.9	17.3	24.1
White spruce	10.0	--	--	6.4	3.6	--
Black spruce	85.0	5.5	28.4	18.9	19.6	12.6
Northern white-cedar	46.3	4.0	17.9	17.6	3.9	2.9
Tamarack	44.0	6.8	20.1	10.8	6.3	--
Oak-hickory	98.5	6.3	39.9	22.0	22.7	7.6
Elm-Ash-Cottonwood	93.8	16.1	30.3	21.1	18.0	8.3
Maple-Basswood	139.5	6.0	32.0	64.4	20.0	17.1
Aspen	1,074.3	25.6	205.4	228.0	216.6	398.7
Paper birch	224.9	5.8	50.5	52.9	56.1	59.6
Balsam poplar	116.9	7.9	40.2	25.6	20.7	22.5
All types	2,222.9	130.1	521.8	524.9	427.5	618.6

Table 5.-- Average annual removals from harvest treatment opportunities by species group and tree class, Minnesota, 1977-1986

(In thousand cubic feet)

Species	All classes	Tree class: Growing stock Total	Growing stock: Pole-timber	Growing stock: Saw-timber	Cull Total	Cull: Short-log	Cull: Other[1/]
SOFTWOODS:							
White pine	5,860	5,649	123	5,526	211	186	25
Red pine	9,906	9,842	639	9,203	64	50	14
Jack pine	14,771	14,290	2,919	11,371	481	338	143
White spruce	8,168	8,104	2,319	5,785	64	48	16
Black spruce	16,223	16,045	10,265	5,780	178	20	158
Balsam fir	22,156	21,544	13,065	8,479	612	259	353
Tamarack	4,389	4,077	2,397	1,680	312	103	209
Northern white-cedar	11,400	9,787	2,554	7,233	1,613	1,237	376
Other softwoods	42	40	20	20	2	1	1
Total	92,915	89,378	34,301	55,077	3,537	2,242	1,295
HARDWOODS:							
White oak	7,110	6,223	2,103	4,120	887	730	157
Select red oak	10,558	9,623	2,488	7,135	935	743	192
Other red oak	53	48	8	40	5	2	3
Hickory	179	168	40	128	11	10	1
Yellow birch	284	150	56	94	134	99	35
Hard maple	2,774	1,574	1,150	424	1,200	807	393
Soft maple	2,808	2,093	1,213	880	715	342	373
Ash	13,113	12,269	7,955	4,314	844	349	495
Balsam poplar	17,227	16,327	7,696	8,631	900	510	390
Paper birch	37,327	34,229	25,447	8,782	3,098	1,409	1,689
Bigtooth aspen	5,365	4,680	2,230	2,450	685	434	251
Quaking aspen	110,608	95,484	41,597	53,887	15,124	9,806	5,318
Basswood	3,813	3,224	1,663	1,561	589	338	251
Elm	6,543	5,884	1,670	4,214	659	566	93
Select hardwoods	284	232	77	155	52	36	16
Other hardwoods	413	327	168	159	86	58	28
Noncommercial species	137	--	--	--	137	--	137
Total	218,596	192,535	95,561	96,974	26,061	16,239	9,822
All species	311,511	281,913	129,862	152,051	29,598	18,481	11,117

[1/] Rough and rotten cull.

Table 6.--Average annual growing-stock removals from harvest treatment opportunities by species group and forest type, Minnsesota, 1977-1986

(In thousand cubic feet)

Species	All types	Forest type													
		Jack pine	Red pine	White pine	Balsam fir	White spruce	Black spruce	Northern white-cedar	Tamarack	Oak-hickory	Elm-ash cotton-wood	Maple-bass-wood	Aspen	Paper birch	Balsam poplar
SOFTWOODS:															
White pine	5,649	59	616	717	427	63	124	40	--	21	8	--	3,066	491	17
Red pine	9,842	584	3,662	166	226	28	63	25	--	148	--	--	3,432	1,508	--
Jack pine	14,290	10,295	34	--	137	2	143	--	16	--	--	--	3,456	188	19
White spruce	8,104	37	15	111	1,287	598	107	23	--	6	64	--	4,774	884	198
Black spruce	16,045	1,229	71	--	2,612	1	7,255	135	306	--	18	--	4,168	167	83
Balsam fir	21,544	119	200	111	5,750	102	208	68	31	11	496	55	10,066	2,999	1,328
Tamarack	4,077	--	--	--	282	1	356	83	2,812	--	17	--	196	--	330
Northern white-cedar	9,787	--	18	--	1,072	107	289	3,368	85	--	1,427	--	1,990	999	432
Other softwoods	40	--	--	--	--	--	--	--	--	17	--	6	--	17	--
Total	89,378	12,323	4,616	1,105	11,793	902	8,545	3,742	3,250	203	2,030	61	31,148	7,253	2,407
HARDWOODS:															
White oak	6,223	5	--	5	--	3	--	--	--	2,866	145	65	2,782	312	40
Select red oak	9,623	26	--	3	--	--	--	--	--	4,596	--	50	4,096	796	56
Other red oak	48	--	--	--	--	--	--	--	--	31	--	--	17	--	--
Hickory	168	--	--	--	--	--	--	--	--	82	--	--	--	86	--
Yellow birch	150	--	--	--	--	--	--	24	--	--	18	--	20	65	23
Hard maple	1,574	--	--	--	29	--	--	--	--	62	13	143	951	325	51
Soft maple	2,093	--	--	2	207	--	--	--	--	72	589	30	1,002	191	--
Ash	12,269	--	--	3	238	--	25	205	5	70	3,327	203	5,978	1,111	1,104
Balsam poplar	16,327	34	--	--	771	1	12	11	14	13	87	6	9,079	421	5,878
Paper birch	34,229	683	91	107	1,313	206	150	169	16	264	387	91	16,207	13,744	801
Bigtooth aspen	4,680	69	44	--	--	--	11	--	--	64	57	--	4,226	189	20
Quaking aspen	95,484	1,093	199	.3	987	64	83	--	6	321	158	19	87,061	3,979	1,511
Basswood	3,224	4	--	--	8	--	--	--	--	381	171	47	2,033	486	94
Elm	5,884	9	--	--	11	--	11	7	7	375	1,407	126	2,914	480	537
Select hardwoods	232	--	--	--	--	--	--	--	--	52	77	21	74	8	--
Other hardwoods	327	16	--	--	--	--	--	--	--	33	239	12	20	--	7
Noncommercial species	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Total	192,535	1,939	334	123	3,564	274	292	416	48	9,282	6,675	813	136,460	22,193	10,122
All species	281,913	14,262	4,950	1,228	15,357	1,176	8,837	4,158	3,298	9,485	8,705	874	167,608	29,446	12,529

Table 7.--Commercial forest area qualifying for timber stand improvement during the decade 1977-1986 by forest type and stand-age class, Minnesota

(In thousand acres)

Forest type	All classes	Stand-age class (years) Less than 21	21-30	31-40	41-50	51-60	61-70	71-80	80+
Jack pine	8.2	--	1.4	6.8	--	--	--	--	--
Red pine	13.7	--	2.3	1.4	1.1	--	--	8.9	--
White pine	3.7	--	--	--	--	1.3	1.3	1.1	--
Balsam fir	19.0	--	--	19.0	--	--	--	--	--
White spruce	6.1	--	1.9	--	1.6	2.6	--	--	--
Black spruce	--	--	--	--	--	--	--	--	--
Northern white-cedar	--	--	--	--	--	--	--	--	--
Tamarack	--	--	--	--	--	--	--	--	--
Oak-hickory	115.5	--	--	42.5	73.0	--	--	--	--
Elm-ash-cottonwood	--	--	--	--	--	--	--	--	--
Maple-basswood	--	--	--	--	--	--	--	--	--
Aspen	--	--	--	--	--	--	--	--	--
Paper birch	--	--	--	--	--	--	--	--	--
Balsam poplar	--	--	--	--	--	--	--	--	--
All types	166.2	--	5.6	69.7	75.7	3.9	1.3	10.0	--

Table 8.--Commercial forest area qualifying for timber stand improvement during the decade 1977-1986 by forest type and stand-volume class, Minnesota

(In thousand acres)

Forest type	All classes	Stand-volume class (cubic foot volume of growing stock per acre) 240-399	400-799	800-1199	1200-1599	1600+
Jack pine	8.2	--	--	--	1.4	6.8
Red pine	13.7	--	--	--	1.1	12.6
White pine	3.7	--	--	--	2.4	1.3
Balsam fir	19.0	--	8.5	4.1	6.4	--
White spruce	6.1	--	1.9	--	--	4.2
Black spruce	--	--	--	--	--	--
Northern white-cedar	--	--	--	--	--	--
Tamarack	--	--	--	--	--	--
Oak-hickory	115.5	1.6	38.2	29.5	31.7	14.5
Elm-ash-cottonwood	--	--	--	--	--	--
Maple-basswood	--	--	--	--	--	--
Aspen	--	--	--	--	--	--
Balsam poplar	--	--	--	--	--	--
All types	166.2	1.6	48.6	33.6	43.0	39.4

Table 9.-- Average annual removals from timber stand improvement treatment opportunities by species group and tree class, Minnesota, 1977-1986

(In thousand cubic feet)

Species	All classes	Tree class					
		Growing stock			Cull		
		Total	Pole-timber	Saw-timber	Total	Short-log	Other[1/]
SOFTWOODS:							
White pine	60	41	2	39	19	--	19
Red pine	61	61	52	9	--	--	--
Jack pine	160	104	63	41	56	26	30
White spruce	17	17	6	11	--	--	--
Black spruce	9	9	9	--	--	--	--
Balsam fir	844	825	701	124	19	4	15
Tamarack	35	35	--	35	--	--	--
Northern white-cedar	--	--	--	--	--	--	--
Other softwoods	12	--	--	--	12	10	2
Total	1,198	1,092	833	259	106	40	66
HARDWOODS:							
White oak	347	138	138	--	209	115	94
Select red oak	648	284	284	--	364	184	180
Other red oak	4	--	--	--	4	4	--
Hickory	31	25	25	--	6	--	6
Yellow birch	--	--	--	--	--	--	--
Hard maple	55	48	48	--	7	7	--
Soft maple	113	103	103	--	10	2	8
Ash	74	73	66	7	1	--	1
Balsam poplar	34	33	33	--	1	--	1
Paper birch	727	580	567	13	147	21	126
Bigtooth aspen	111	88	77	11	23	17	6
Quaking aspen	1,326	966	630	336	360	144	216
Basswood	248	144	132	12	104	11	93
Elm	159	154	145	9	5	5	--
Select hardwoods	43	31	22	9	12	2	10
Other hardwoods	5	5	5	--	--	--	--
Noncommercial species	7	--	--	--	7	--	7
Total	3,932	2,672	2,275	397	1,260	512	748
All species	5,130	3,764	3,108	656	1,366	552	814

[1/] Rough and rotten cull.

Table 10.--Average annual growing-stock removals from timber stand improvement treatment opportunities by species group and forest type, Minnsesota, 1977-1986

(In thousand cubic feet)

Species	All types	Forest type[1/]						
		Jack pine	Red pine	White pine	Balsam fir	White spruce	Oak-hickory	Maple-basswood
SOFTWOODS:								
White pine	41	--	12	--	--	13	16	--
Red pine	61	--	61	--	--	--	--	--
Jack pine	104	28	--	46	--	30	--	--
White spruce	17	--	--	--	--	11	6	--
Black spruce	9	--	--	--	--	9	--	--
Balsam fir	825	--	--	--	662	163	--	--
Tamarack	35	--	--	--	--	35	--	--
Northern white-cedar	--	--	--	--	--	--	--	--
Other softwoods	--	--	--	--	--	--	--	--
Total	1,092	28	73	46	662	261	22	
HARDWOODS:								
White oak	138	3	--	--	--	--	135	--
Select red oak	284	--	--	--	--	--	284	--
Other red oak	--	--	--	--	--	--	--	--
Hickory	25	--	--	--	--	--	25	--
Yellow birch	--	--	--	--	--	--	--	--
Hard maple	48	--	--	--	--	--	48	--
Soft maple	103	--	--	--	--	--	103	--
Ash	73	--	--	--	--	--	73	--
Balsam poplar	33	--	--	--	--	23	10	--
Paper birch	580	--	6	--	--	18	556	--
Bigtooth aspen	88	--	--	--	--	--	88	--
Quaking aspen	966	8	--	119	362	139	338	--
Basswood	144	--	--	--	--	--	144	--
Elm	154	--	--	--	--	--	154	--
Select hardwoods	31	--	--	--	--	--	31	--
Other hardwoods	5	--	--	--	--	--	5	--
Noncommercial species	--	--	--	--	--	--	--	--
Total	2,672	11	6	119	362	180	1,994	--
All species	3,764	39	79	165	1,024	441	2,016	--

[1/] Only the forest types listed in the table were assigned t.s.i. criteria.

Table 11.--Area of commercial forest land qualifying for stand conversion or restocking during the decade 1977-1986 by forest type and stand-age class, Minnesota

(In thousand acres)

Forest type	All classes	Stand-age class (years)												
		1-10	11-20	21-30	31-40	41-50	51-60	61-70	71-80	81-90	91-100	101-120	121-140	141+
Jack pine	19.2	7.3	5.7	3.8	2.4	--	--	--	--	--	--	--	--	--
Red pine	7.8	5.7	1.2	0.9	--	--	--	--	--	--	--	--	--	--
White pine	3.1	--	3.1	--	--	--	--	--	--	--	--	--	--	--
Balsam fir	58.1	16.6	18.9	11.6	2.7	1.7	3.3	2.0	1.3	--	--	--	--	--
White spruce	12.4	5.4	5.5	1.5	--	--	--	--	--	--	--	--	--	--
Black spruce	146.4	45.4	24.8	35.9	14.3	6.0	8.5	--	8.1	1.8	1.6	--	--	--
Northern white-cedar	52.2	3.6	5.9	5.7	--	--	1.4	4.2	5.6	3.0	5.8	8.8	8.2	--
Tamarack	114.8	29.4	38.3	15.7	9.3	4.2	4.9	3.0	4.2	1.2	--	3.4	1.2	--
Oak-hickory	59.1	19.4	14.2	6.9	3.1	1.7	3.1	6.2	1.5	1.3	1.7	--	--	--
Elm-ash-cottonwood	99.1	33.9	20.9	13.9	7.3	1.7	2.7	5.5	5.1	4.9	3.2	--	--	--
Maple-basswood	91.8	15.3	24.1	10.7	6.0	9.9	14.0	3.2	3.9	3.1	1.6	--	--	--
Aspen	504.7	228.8	134.0	74.3	34.0	17.0	14.9	1.7	--	--	--	--	--	--
Paper birch	53.3	17.0	11.2	5.8	7.5	3.1	2.1	4.4	0.8	--	--	1.4	--	--
Balsam poplar	94.5	35.4	33.0	11.7	7.2	3.0	3.4	0.8	--	--	--	--	--	--
All types	1,316.5	463.2	340.8	198.4	93.8	48.3	58.3	31.0	30.5	15.3	13.9	13.6	9.4	--

Table 12.--Growing-stock volume on stands selected for stand convesion or restocking by species and tree class, Minnesota, 1977-1986

(In thousand cubic feet)

Species	All classes	Tree class					
		Growing stock			Cull		
		Total	Pole-timber	Saw logs	Total	Short-log	Other[1/]
SOFTWOODS:							
White pine	2,207	1,932	1,904	28	275	54	221
Red pine	1,815	1,693	1,468	225	122	--	122
Jack pine	6,041	4,601	1,836	2,765	1,440	206	1,234
White spruce	3,071	2,830	1,467	1,363	241	--	241
Black spruce	14,102	11,474	4,062	7,412	2,628	139	2,489
Balsam fir	12,465	9,590	3,239	6,351	2,875	467	2,408
Tamarack	16,551	10,377	3,564	6,813	6,174	380	5,794
Northern white-cedar	6,548	2,407	1,171	1,236	4,141	807	3,334
Other softwoods	281	--	--	--	281	--	281
Total	63,081	44,904	18,711	26,193	18,177	2,053	16,124
HARDWOODS:							
White oak	8,348	2,214	1,168	1,046	6,134	1,876	4,258
Select red oak	4,545	1,567	1,118	449	2,978	417	2,561
Other red oak	644	644	604	40	--	--	--
Hickory	541	514	493	21	27	--	27
Yellow birch	97	--	--	--	97	--	97
Hard maple	3,376	832	579	253	2,544	354	2,190
Soft maple	4,299	1,222	535	687	3,077	194	2,883
Ash	19,742	13,853	6,048	7,805	5,889	298	5,591
Balsam poplar	14,163	11,084	5,893	5,191	3,079	356	2,723
Paper birch	19,965	13,135	4,515	8,620	6,830	668	6,162
Bigtooth aspen	699	528	234	294	171	--	171
Quaking aspen	75,932	45,792	17,702	28,090	30,140	2,517	27,623
Basswood	2,572	1,344	520	824	1,228	292	936
Elm	13,345	7,719	3,633	4,086	5,626	2,169	3,457
Select hardwoods	791	410	331	79	381	103	278
Other hardwoods	2,991	1,176	325	851	1,815	248	1,567
Noncommercial species	2,221	--	--	--	2,221	--	2,221
Total	174,271	102,034	43,698	58,336	72,237	9,492	62,745
All species	237,352	146,938	62,409	84,529	90,414	11,545	78,869

[1/] Rough and rotten cull.

Table 13.--Growing-stock volume on stands selected for stand conversion or restocking by species group and forest type, Minnsesota, 1977-1986

(In thousand cubic feet)

Species	All types	Forest type													
		Jack pine	Red pine	White pine	Balsam fir	White spruce	Black spruce	Northern white-cedar	Tamarack	Oak-hickory	Elm-ash-cotton-wood	Maple-bass-wood	Aspen	Paper birch	Balsam poplar
SOFTWOODS:															
White pine	1,932	42	--	159	339	144	77	339	--	20	--	125	687	--	--
Red pine	1,693	296	--	216	--	--	--	--	--	71	--	--	1,110	--	--
Jack pine	4,601	2,016	151	--	--	--	--	--	--	212	--	527	1,525	102	68
White spruce	2,830	90	--	--	215	115	--	238	118	319	157	251	1,022	73	232
Black spruce	11,474	--	--	82	853	--	6,188	1,277	1,673	--	--	--	1,272	--	129
Balsam fir	9,590	--	--	--	2,273	50	458	2,835	252	132	507	351	2,466	180	86
Tamarack	10,377	--	--	--	292	--	1,533	359	6,434	--	430	85	382	472	390
Northern white-cedar	2,407	--	--	--	525	--	--	770	316	--	223	--	216	195	162
Other softwoods	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Total	44,904	2,444	151	457	4,497	309	8,256	5,818	8,793	754	1,317	1,339	8,680	1,022	1,067
HARDWOODS:															
White oak	2,214	--	--	--	--	--	--	--	--	129	23	320	1,592	--	150
Select red oak	1,567	141	--	--	--	--	--	--	--	--	--	692	734	--	--
Other red oak	644	--	--	--	--	--	--	--	--	--	302	342	--	--	--
Hickory	514	--	--	--	--	--	--	--	--	514	--	--	--	--	--
Yellow birch	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Hard maple	832	--	--	--	--	--	--	--	--	--	--	396	436	--	--
Soft maple	1,222	--	--	--	--	--	--	--	--	--	249	457	379	137	--
Ash	13,853	--	--	--	132	--	15	96	--	177	6,358	5,036	1226	122	691
Balsam poplar	11,084	--	--	--	---	--	--	--	30	--	854	79	4,751	839	4,531
Paper birch	13,135	203	--	--	580	58	191	91	339	266	140	838	6,805	3,306	318
Bigtooth aspen	528	--	--	--	--	--	--	--	--	40	115	80	293	--	--
Quaking aspen	45,792	--	--	--	570	--	790	50	322	574	675	1,424	37,875	945	2,567
Basswood	1,344	--	--	--	--	--	--	--	--	--	303	728	313	--	--
Elm	7,719	--	--	--	100	--	--	--	--	1,484	1,693	2,336	1,981	--	125
Select hardwoods	410	--	--	--	--	--	--	--	--	132	220	58	--	--	--
Other hardwoods	1,176	--	--	--	--	--	--	--	--	112	838	226	--	--	--
Noncommercial species	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Total	102,034	344	--	--	1,382	58	996	237	691	3,428	11,770	13,012	56,385	5,349	8,382
All species	146,938	2,788	151	457	5,879	367	9,252	6,055	9,484	4,182	13,087	14,351	65,065	6,371	9,449

Table 14.--Commercial forest area requiring no treatment by forest type and stand age class, Minnesota, 1977-1986

(In thousand acres)

Forest type	All classes	Stand-age class (years)												
		1-10	11-20	21-30	31-40	41-50	51-60	61-70	71-80	81-90	91-100	101-120	121-140	141+
Jack pine	385.7	18.1	13.3	59.3	89.8	113.7	70.6	20.7	0.2	--	--	--	--	--
Red pine	202.2	4.6	37.5	8.8	26.6	18.8	14.5	13.5	38.6	15.1	24.2	--	--	--
White pine	52.9	2.1	0.2	--	1.3	8.9	2.8	8.1	7.5	3.9	14.5	3.6	--	--
Balsam fir	623.8	33.9	49.5	66.6	79.9	219.1	146.2	27.1	--	1.5	--	--	--	--
White spruce	50.7	8.8	1.7	1.4	8.2	17.2	12.0	1.4	--	--	--	--	--	--
Black spruce	841.4	33.1	78.3	138.1	150.1	111.6	121.8	69.6	64.4	42.1	28.8	3.5	--	--
Northern white-cedar	403.7	3.0	4.4	19.1	21.7	18.1	39.4	57.5	46.7	58.3	63.7	48.1	23.7	--
Tamarack	323.4	17.9	40.3	33.3	21.9	34.2	63.6	22.0	24.9	34.1	8.3	20.5	2.4	--
Oak-hickory	629.8	17.8	24.4	6.5	19.2	64.7	126.1	130.4	92.9	71.3	70.4	6.1	--	--
Elm-ash-cottonwood	562.8	30.5	30.2	33.2	32.7	76.7	117.6	83.8	61.0	65.4	31.1	0.6	--	--
Maple-basswood	1,056.9	19.3	26.7	30.5	89.9	190.6	220.3	188.3	152.3	87.8	49.2	2.0	--	--
Aspen	3,782.6	509.6	384.0	401.5	870.6	1,199.2	415.8	1.9	--	--	--	--	--	--
Paper birch	728.5	23.9	48.7	28.7	112.0	260.6	229.7	17.9	--	3.1	3.7	0.2	--	--
Balsam poplar	345.1	37.6	45.0	31.9	82.7	111.3	36.6	--	--	--	--	--	--	--
All types	9,989.5	760.2	784.2	858.9	1,606.6	2,444.7	1,617.0	642.2	488.5	382.6	293.9	84.6	26.1	--

Table 15.--Area of commercial forest land qualifying for stand conversion or restocking by forest type and tree class, Minnesota, 1977.

(In thousand acres)

Forest type	All classes	Tree class		
		Nonstocked	Seedlings and saplings	Poletimber or sawtimber
Jack pine	19.2	2.7	15.2	1.3
Red pine	7.8	--	7.8	--
White pine	3.1	--	3.1	--
Balsam fir	58.1	8.4	41.4	8.3
Black spruce	146.4	31.0	100.9	14.5
White spruce	12.4	--	12.4	--
Northern white-cedar	52.2	3.6	13.1	35.5
Tamarack	114.8	16.8	86.4	11.6
Oak-hickory	59.1	9.0	28.8	21.3
Elm-ash-cottonwood	99.1	17.6	60.0	21.5
Maple-basswood	91.8	4.3	47.0	40.5
Aspen	504.7	59.3	387.3	58.1
Paper birch	53.3	9.1	29.0	15.2
Balsam poplar	94.5	7.6	72.4	14.5
All types	1,316.5	169.4	904.8	242.3

Smith, W. Brad, and Pamela J. Jakes.

1981. Projecting treatment opportunities for current Minnesota forest conditions. U.S. Department of Agriculture Forest Service, Research Paper NC-215, 21 p. U.S. Department of Agriculture Forest Service, North Central Forest Experiment Station, St. Paul, Minnesota.

Reviews opportunities for treatment of timber stands in Minnesota for the decade 1977-1986. Under the assumptions and management guides specified, 27 percent of Minnesota's commercial forest land would require timber harvest or some other form of treatment during the decade.

KEY WORDS: forest management, treatment opportunities, timber harvest.

☆ U. S. GOVERNMENT PRINTING OFFICE: 1981—767-423/43